ATTACHMENT A

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s):	Hua Ji		
Assignee:	Mosel Vitelic, Inc.		
Title:	HDP CVD Process For Void-Free Gap Fill Of A High Aspect Ratio Trench		
Serial No.:	10/080,468	Filing Date:	February 22, 2002
Examiner:	Anh D. Mai	Group Art Unit:	2814
Docket No.:	M-12589 US		

Irvine, California
May 12, 2004

COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, VA 22313-1450

DECLARATION OF LARRY CHEN UNDER RULE 1.132

I, Larry Chen, declare as follows:

1. I have been a process engineer at Mosel Vitelic Inc., the assignee of the aforementioned patent application, since 2002, and am currently a manager in the CVD unit.

2. I received a Bachelor of Science degree in chemical engineering from National Taiwan University in 1986, and a Ph.D. from the University of Minnesota, Twin Cities, in 1996.

3. I have been employed as a process engineer in the semiconductor industry for the last 9 years.

4. I have read and am familiar with the aforementioned patent application and its prosecution history up to the present time, as well as the development and current state of high density plasma chemical vapor deposition (HDP CVD) techniques and systems used in semiconductor manufacturing.

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THE PRESENT INVENTION

5. The present invention provides a method of filling high aspect ratio gaps without the void formations typical of the prior art. In one embodiment, a single gas mixture is provided with a low ratio of the oxygen-containing component to the silicon-containing component and/or a low concentration of the oxygen-containing component to form a film of a selected refractive index without cusp formation and in a single process step.

6. Advantageously, gaps with aspect ratios over 4.0:1 and with widths of 0.1 micron have been filled with stoichiometric films without the formation of voids. The electrical performance of non-stoichiometric films is inferior because they are less dense, and their electrical isolation properties are not as good. If the Si:O ratio is not controlled in the deposited film, the isolation properties of the deposited film may not meet the device electrical requirements.

7. The Applicant disclosed an etch-to-deposition (E/D) ratio defined by the equation: E/D = (UBUC-BUC) / UBUC, where UBUC is the deposition rate of the process with no wafer bias or clamping (unbiased, unclamped), and BUC is the deposition rate of the process with wafer and no clamping (biased, unclamped). (Applicant's Specification, page 8, lines 6-13).

8. The Applicant further disclosed that E/D ratios from about 0.0 to about -0.05 have been achieved for void-free gap filling, where the UBUC refractive index ranges from about 1.5 to about 1.6. (Applicant's Specification, page 8, lines 19-22).

9. The Applicant further disclosed in Table 1 "process parameter ranges . . . to form a silicon dioxide layer with a refractive index of 1.46." (Applicant's Specification as filed, page 9, lines 7-16). In other words, the film deposited under BUC conditions has a refractive index of about 1.46.

10. In my opinion, when the deposition rate of the process is measured with no wafer bias or clamping (UBUC) and no gas flow change (e.g., no increased O_2 levels), the UBUC-deposited film refractive index changes as compared to the BUC-deposited film refractive

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index. The deposition rate of UBUC is larger than the deposition rate of BUC for the same film having the same refractive index but is NOT always larger for different films having different refractive indices. In other words, the films being deposited in the two cases are of different composition (more or less silicon-richness). Accordingly, under some conditions for low deposition rates and high aspect ratio gaps, the deposition rate with bias (BUC) may be larger than the deposition rate without bias (UBUC) and therefore the E/D ratio, as defined by the Applicant, may be negative in some cases.

11. The Applicant discloses the critical nature of the reduced oxygen levels by stating that "the reduced flow rate or concentration of oxygen required for a selected flow rate or concentration of silane reduces the main sputtering component of the gas mixture, resulting in a reduction of sidewall redeposition, thereby helping to keep the gap open for filling." (Specification, page 7, line 31 – page 8, line 2).

THE PAPASOULIOTIS REFERENCE

12. In my opinion, U.S. Patent No. 6,030,881 to Papasouliotis et al. (hereinafter "Papasouliotis") stands in sharp contrast to the present invention. Papasouliotis discloses deposition/etch cycling using different gas mixtures having different etch/dep ratios to fill the gap. In particular, Papasouliotis discloses a "composite multi-step HDP-CVD process" (Papasouliotis, col.4, lines 55-56) and "multiple sequential deposition and etch steps of different etch rate-to-deposition rate (etch/dep) ratios to fill high aspect ratio gaps" (Papasouliotis, col. 5, lines 19-21). The first step is a deposition step in which "[c]usps 530 begin to form at the corners of circuit elements 520 as SiO_2 layer 525 fills gap 510, as shown in FIG. 5A. Before cusps 530 close the entry to gap 510, the deposition step is stopped." (Papasouliotis, col. 5, lines 58-61). The "deposition/etching cycle is repeated as many times as necessary until the resulting gap can be filled by a conventional HDP deposition step (FIG. 5A) without void formation, as shown in FIG. 5C." (Papasouliotis, col. 6, lines 9-12). Accordingly, Papasouliotis discloses a conventional HDP deposition step in which cusps are formed during deposition to fill a gap and voids will be formed if etch cycling with a different gas mixture is not performed.

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13. The Examiner has stated the following regarding the Papasouliotis reference:

> [T]o find the flow ratio, one should look into the tables. For example, in table 1, the oxygen (claimed oxygen-containing components) flow rate 10-1000 sccm and the silane flow rate (silicon-containing components) 10-250 sccm. So, the flow ratio of oxygen-containing components to the silicon-containing components, as disclosed in tables 1 is 1:1 to 4:1. Note that, these [sic] ratio also includes below 1.3. (Office Action dated May 27, 2003, page 9).

14. Papasouliotis only discloses in its Tables 1-4 an extremely wide range of flow rates for oxygen and silane. However no mention is made of the ratio of these two components, oxygen concentration, optimizing composition, or even a refractive index.

15. Furthermore, Papasouliotis does not disclose or suggest a negative etch/dep ratio.

16. Determining the optimum ratio of the oxygen-containing component to silicon-containing component, in view of Papasouliotis, would not have been accomplished through routine experimentation but instead would have required extraordinary experimentation because non-linear extrapolation would be required to optimize the E/D ratio or composition of the reactive gas mixture within the ranges specified in Papasouliotis.

17. Instead, Papasouliotis discusses deposition/etch cycling and "the need for optimizing the duration of deposition steps." (Papasouliotis, col.6, ll.66-67). Optimizing duration of deposition steps involved in cycling teaches away from an optimum composition of reactants for a single duration step, which may not be efficient or optimal in terms of step duration.

18. In my opinion, it would not have been obvious to one of ordinary skill in the art in view of Papasouliotis to determine the optimum ratio of the oxygen-containing component to silicon-containing component or the optimal concentration of oxygen in the gas mixture as claimed in the present invention, given that Papasouliotis does not mention the ratio, oxygen concentration, optimizing composition, or refractive index.

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19. Even assuming arguendo that Papasouliotis were to disclose a ratio of the oxygen flow rate to the silane flow rate as proposed by the Examiner, Papasouliotis does not disclose or suggest a gas mixture including an oxygen-containing component that is no more than 21% total concentration by volume of the gas mixture. As noted by the Examiner above, "in table 1, the oxygen (claimed oxygen-containing components) flow rate [is] 10-1000 sccm and the silane flow rate (silicon-containing components) [is] 10-250 sccm. So, the flow ratio of oxygen-containing components to the silicon-containing components, as disclosed in tables 1 is 1:1 to 4:1." Using such a linear extrapolation, Papasouliotis does not disclose or suggest a gas mixture including an "oxygen-containing component" that is "no more than 21% total concentration by volume of said gas mixture" as claimed in Claims 1, 19, and 30 (e.g., from the data in Table 1, the minimum concentration of oxygen is 10/(10+10+10) = 33%; from the data in Table 2, the minimum concentration of oxygen is 1000/(1000+1000+500+60) = 39%; from the data in Table 3, the minimum concentration of oxygen is 500/(500+600+170+250) = 33%; from the data in Table 4, the minimum concentration of oxygen is 700/(700+1000+300+30) = 34%).

20. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that the statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under § 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the above application and any patent issued thereon.

Larry Chen

5/12/04

Date

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